PROBLEM-SOLVING SKILLS, PROCESSING SPEED INDEX AND REASONING SKILLS AS DETERMINANTS OF THE EXECUTIVE FUNCTIONING IN THE STUDENTS WITH DYSCALCULIA

A
SYNOPSIS

Submitted to
Dayalbagh Educational Institute
(Deemed University)
For the Requirements for the Degree of
DOCTOR OF PHILOSOPHY
IN
EDUCATION
(March, 2016)

Supervisor
Prof. K.C. Vashistha

Researcher
Aditi Bapte

FACULTY OF EDUCATION
DAYALBAGH EDUCATIONAL INSTITUTE
(DEEMED UNIVERSITY), DAYALBAGH, AGRA
(282005)

1.0.0 INTRODUCTION

Learning Disabilities (LD) is the term assigned to specific problems in the sphere of learning which encompasses reading, writing, speaking, and mathematics. Learning Disabilities brings about a handicap in the various spheres may be individually and many a times in concurrence with other learning disabilities which is often referred to as learning disability co-morbidity. A person with disability in Mathematics may have a co-morbidity with Reading too. Learning Disability is a large canopy. But, the irony of the situation remains that these learning disabilities go unobserved and undetected in students by the teachers, parents and physicians. It is for the same reason that they are also referred as the hidden handicaps. These handicap the very learning process in reference to reading (Dyslexia), writing (Dysgraphia) and numbers (Dyscalculia).

One such prominent disability in learning is Dyscalculia also referred to as 'Mathematics Learning Disability' and often stated as "number blindness" (Butterworth, 2009). It is the Learning Disability that is related to the lack of perception of the numbers and symbols. The students with Dyscalculia are commonly called as Dyscalculics and usually show difficulty in counting numbers, learning maths concepts, math calculations, difficulty in measurement, time-telling, mental math and problem-solving. It is hard to define it as there is already an ambiguity regarding the variation in the terms various people have assigned to this disability. For instance Kosc (1974) marked it as 'developmental dyscalculia', Hitch et al., (1994) derived the term 'specific arithmetic difficulties' while Butterworth (2003) preferred the term 'dyscalculia'. It is for the same that this diversity is seen in the definitions that are used to describe Dyscalculia.

Diagnostic and Statistical Manual of Mental Disorders (DSM-IV, 1994), defines the term as 'Mathematics Disorder': *Mathematical ability as measured by individually administered standardized tests, is substantially below that expected given the person's chronological age, measured intelligence and age appropriate education, which significantly interferes with academic achievement or activities of daily living that require mathematics ability.* Similarly, the Department of Education and Skills, UK (DfES, 2001) defines Dyscalculia as- *A condition that affects the ability to acquire arithmetic skills. Dyscalculic learners may have difficulty understanding simple number concepts, lack an intuitive grasp of numbers, and have problem*

learning number facts and procedures. Even if they produce a correct answer or use a correct method, they may do so mechanically and without confidence.

Kosc (1974) had made attempt to classify Dyscalculia in six different types which was later followed by Rosselli and Ardila (1997), with little modification on the basis of the struggle faced by the learners in various mathematical tasks in their regular classroom practices. A comparative view of these classification is given in Table 1.1.

Table 1.1 A Classification of Dyscalculia by Kosc (1974) and Rosselli & Ardilla (1997)

SN	Kosc's Classification (1974)	Rosselli & Ardila's Classification (1997)	Description of the Terms (A difficulty exhibited in)
1	Lexical Dyscalculia	Alexic Acalculia	Mathematics symbols such as numerals
2	Graphical Dyscalculia	Agraphic Acalculia	Writing mathematics symbols
3	Verbal Dyscalculia	Aphasic Acalculia	Mathematical concepts in oral language
4	Practognostic Dyscalculia	Spatial Acalculia	Concrete materials, or enumerating a quantity
5	Ideognostic Dyscalculia	Ideognostic Dyscalculia	Math ideas and relationships
6	Operational Dyscalculia	Frontal Acalculia	Performing specified mathematical operations

Later on Geary (2000) consolidated classification of Dyscalculia into three distinct groups: Semantic, Procedural, and Visual-spatial Memory. Where, (i) Semantic Memory represents the problem in retrieving the numeral information, (ii) Procedural Memory relates to the problem in understanding and using the numeral procedures and (iii) Visio-spatial Memory relates to the problem in comprehending numero-spatial information, like geometry etc.

Butterworth (1999) revealed that students with Dyscalculia commonly depend on "immature strategies" like finger-counting and have difficulty in learning and remembering Mathematical facts (Shalev & Gross-Tsur, 2001). The researchers have also reported a significant connection of defective spatial abilities which affect the sense of number processing in these students (Dehaene, Piazza, Pinel, & Cohen, 2003). Thus, generally Dyscalculics show unusually poor performance on very simple tasks of numerosities. A more surprising presumption associated to Dyscalculia is that is no agreed upon benchmark available for diagnosing Dyscalculia and some

also blame the numeral anomalies to the lack of attention by the teacher or laziness on the part of the student. It is for the very reason that different magnitudes of its prevalence rates are reported in by Indian researches as well as in abroad.

Table 1.2: Exhibiting the Prevalence Rate of Dyscalculia in school-going population arranged in the Descending order (In Year-wise Descending order)

SN	Researcher	Reporting Year	Prevalence Rate of students with Dyscalculia
1	Ramma & Gowramma	2002	5.98%
2	Shalev et al.	2004	5%-6%
3	Butterworth	2005	3.6%-6.5%
4	Price et al.	2007	3%- 6%
5	Barahmand	2008	3.76%
6	Vijaylaxmi	2009	10.48%
7	Crespo et al.	2011	3.40%
8	Mogasale et al.	2012	10.50%
9	Jovanvic et al.	2013	3%- 6.5%
10	Nojabaee et al.	2014	1.49%- 1.57%

As highlighted the scenario of Prevalence of Dyscalculia at abroad and at home it clearly draws attention to the fact that is on an average Dyscalculia is between 3-6 percent of the world's population and the estimated prevalence rate is similar to Dyslexia (Butterworth, 2003). Yet this field of Dyscalculia is remained under-resourced and under- researched in all these years. Indeed it puts a person a step behind when compared to his/her peers, because numeracy is getting centralized position and a much needed skill in todays' world. It is alone emerged out as one of the major cause of school dropouts, anxiety, emotional effects and strained cognitive functions in present time. Butterworth (2003) refers that students with Dyscalculia seem to be born with a deficit that makes numeracy skills more difficult. It is in turn hereditary and the prevalence rate as cited for Dyscalculia is similar to Dyslexia. But unlike Dyslexia, Dyscalculia is not universally recognized by the disability workers and their stake-holders to do the justice with this field of research as well as the large chunk of students affected by the menace of Dyscalculia.

1.1.0 THEORETICAL FRAME WORK OF CONSTRUCTS

The researcher has put forth a great emphasis after exhaustive study of the existing researches in this virgin field in terms of novelty, universality and validity of the constructs in the contemporaneity and futuristic implications in inclusive education setup. After deep pondering over the literature at hand and probing the following constructs are selected in final phase.

1.1.1 EXECUTIVE FUNCTION

Executive function (EF) are set of cognitive constructs or processes that allow us to respond flexibly to our environment and involve in considerate, goal-oriented, thought and action.

Executive function forms the basis of abilities such as Problem-solving and flexible thinking and is most likely to be used in the absence of external guidance or when a situation is new. For example, when the driver is driving then the activation to apply brakes on seeing the red signal is a case of routine tasks where through practice we have acquired a set approach of behaving. But when it comes to novel and unrehearsed situations, it is again the task of the Executive system of your brain to function and devise a solution quickly. Executive functions are the high level cognitive processes that facilitate new ways of behaving, and optimise one's approach to unfamiliar circumstances. Executive function skills begin to emerge in infancy (Diamond, 2011) but are among the last cognitive abilities to mature, continuing to develop into late adolescence (Huizinga et al., 2006).

The major problem in the research conducted in the sphere of Executive functioning is the problem in quantifying these cognitive processes. But over the recent times as there have been advances a number of tasks have been used on humans like the Wisconsin Card Sorting Test, the Trail Making Test, Stroop Test to name a few have been employed successfully on humans. A brief review of the researcher's application to measure this construct is given here along with the variety of internationally recognized tests, they have applied for.

Table 1.3 Exhibiting the Available Tests on Executive Functioning

S N	Researcher	Tests used to measure Executive functioning	Components of Constructs Assessed
1	Heaton, Chelune, Talley, Kay, & Curtiss, (1993)	Wisconsin Card Sorting Test (WCST)	Switching & Preservation
2	Jones-Gotman& Milner, (1977)	Verbal Fluency Test	Verbal Component
3	Jones-Gotman& Milner, (1977)	Design Fluency Test	Non-verbal Component
4	Burgess &Shallice, (1996)	Stroop Test	Verbal Inhibition
5	Humes et al., (1997)	Tower of Hanoi	Planning
6	Robertson et al., (1997)	Sustained Attention to Response Task	Sustained Attention and Inhibition
7	Callicott et al., (1998)	N- back Test	Online Monitoring and Updating
8	Burgess et al., (2000)	Greenwich Test	Executive Memory and Planning
9	Schwartz et al., (2002)	Naturalistic Planning Test	Planning, Sequencing and Strategy
10	Kaplan (2001); Crawford et al. (2011)	D-KEFS Test	Flexibility, Planning, Fluency, Memory & Inhibition

It is vividly evident from the table summary that the Executive functions are most commonly studied, as (i) Inhibition (suppressing distracting information and unwanted responses), (ii) Shifting (flexibly switching between different tasks) and (iii) Updating or Working Memory (monitoring and manipulating information in mind) (Miyake et al, 2000). These available tests of Executive functioning show the various components that are assessed like planning, switching, verbal, non-verbal component, attention, memory and so forth.

A number of skills come under these two dimensions of executive functioning viz., Cold and Hot Executive functions. The verbal reasoning, planning, sequencing, problem-solving, sustained attention, cognitive flexibility, inhibition and the ability to deal in novel situations all come under the subhead of Cold components of Executive function (Burgess, Veitch de lacy Costello, & Shallice, 2000). It is for the reason that these cognitive processes lack emotional arousal and are more logical in nature. While the Executive functions involving emotions or desires like social inhibition, experience of reward or punishment, etc. are called the Hot component of the Executive functioning. Similarly, the five areas of Executive functioning are (i) Organizing, (ii) Prioritizing/Planning, Shifting/ Thinking Flexibility, (iv) accessing Working memory, and

(v)Self-monitoring (National Centre for Learning Disabilities, 2013). On the other hand Dawson & Gaure (2008) referred eleven components or skills of Executive functioning being, (i) Response Inhibition, (ii) Working Memory, (iii) Emotional control, (iv) Sustained attention, (v)Task initiation, (vi) Planning/ Prioritizing, Organization, (vii) Time-management, (viii) Goal-directed persistence, (ix) Flexibility, (x) Metacognition and (xi) Stress tolerance. The commonality among these tasks is that they are beyond the routine stimulus- response pattern and provides the respondent a novel and dynamic situation each time and aims to encompass the various dimensions of Executive Functioning like Inhibition, Verbal and Non-verbal component, Planning, Sequencing, etc.

The majority of studies addressing the role of working memory in mathematics are based on the working memory model of Baddeley and Hitch (1974) which sees the Central Executive System as the controller of the verbal and visuo-spatial information that we come across in our lives. When the word Red is written in the colour Blue in different contexts we might read the word Red and ignore the visual-processing of the colour as demonstrated in the Stroop test (Burgess & Shallice, 1996). But it is the EF skills that link our motor and visual skills and so forth. EF plays an important part when it comes to the academic success and social success and a problem in EF is the direct link to emotional problems (Lehto, Juujarvi, Kooistra, & Pulkkinen, 2003). Many a times poor EF is an indicator of aggressive behaviour and many researchers have reported this to be the cause of ADHD, too. EF is direct indicator of academic success and predict math and reading competence. Cantin and Rachelle (2013) inferred from a longitudinal study that better EF during preschool predicted better math performance in middle childhood. Hence, EF moulds the path to being focussed in both practised and novel situations and giving a well-thought rather than an impulsive response.

1.1.2 PROBLEM-SOLVING SKILLS

Problem-solving is generally regarded as the most important cognitive activity in one's daily life and in the professional arena one is actually paid for solving problems at the work place. But when it comes to the educational settings the process of solving problems is never given a formal importance, and remain unattended due to our limited proficiency in this area of research. The

instructions in the common classroom lack the thorough knowledge and implementation of the skills of Problem solving. In its true eventuality after all Problem-solving is and should be the true result of one's day-to-day life.

According to Sezetela & Nicol (1992), *Problem-solving is the process of confronting a novel situation formulating connections between given facts, identifying the goal and exploring possible strategies for reaching the goal.*

A Problem is then a situation in which initially a sure shot procedure is not known to the individual but the individual desires to search the solution. All the major child-centred designs like: goal-based learning, open-ended learning and even the problem-based learning focus on Problem-solving results. All the methods of Scaffolding, Simulation, etc. propose the solving of problems (Jonassen, 2000). Generally Problems are of two types: (i) ill-structured problems and (ii) well-structured problems. Ill-structured problems are those that do not have clear aim or expected solution. Well-defined problems have specific goals and clear expected solutions (Jonassen, 1997). These problems also allow for more initial planning than ill-defined problems. Being able to solve problems sometimes involves dealing with logic and interpretation of the problem.

Initially, Problem-solving was seen as a context, with an objective to teach various subjects, especially mathematics and to inculcate other skills in a student. It was later on that Problem-solving was also viewed as a skill. Thus, Problem-solving was no more limited to being a means of developing skills but a necessary skill to be taught (Sezetela & Nicol, 1992). The Problem-solving Skills also find its way into the ten generic Life Skills proposed by WHO (1999) which defines it as: *"The Skills which enables us to deal constructively with problems in our lives."* Problem solving has two major domains: mathematical problem solving and personal problem solving where, in the second, some difficulty or barrier is encountered. The steps in this sequence are arranged in a circle to emphasize the cyclical and continuous nature of the problem solving process. The POWER. Model as proposed by Namibia Youth Programme: My Future, My Choice (UNICEF, Namibia, 1999). Each step is followed by another and every step is a precursor

and has to be followed meticulously to achieve the true purpose of solving a problem. For which the abbreviations of the POWER Model has to be understood first.

Table 1.4 Exhibiting the details of the POWER Model of Problem-solving Skills

SN	Abbreviation	Details	Expression of the Abbreviation
1	P	Power	Stop and state (or identify) the problem
2	O	Options	Think of different things you can do and use them. The more options you have, the better.
3	W	Weigh	Look at the good things and weigh them against the bad things of every option you thought of to solve your problem. The things you value should guide you in your decision making.
4	E	Elect	Choose the best option, talk to a person you respect, then take the best action. Elect the option which obtains what is important to you
5	R	Reflect	Think or reflect about what happened because of your decision

Problem-solving skills can only be applied and will be fruitful unless the problem is known. It is then that the next step follows, i.e., identifying the cause and the alternative solutions to the problem at hand, implementing the chosen solution but the process does not end here as it lays equal importance to the component of evaluation or review and the cyclic nature of Problem-solving allows review and revision at each step. The ability to understand what the goal of the problem is and what rules could be applied represent the key to solving the problem. Considered the most complex of all intellectual functions, Problem-solving has been defined as a higher order cognitive process that requires the modulation and control of more routine or fundamental skills.

1.1.3 PROCESSING SPEED INDEX

People process information at different rates, and these differences appear to matter in one's life. Individual differences in processing speed are believed to reflect variation in neural speed, efficiency, and capacity (Birren & Fisher, 1995; Mendelson & Ricketts, 2001). The brain requires time and capacity to process information and plan an appropriate response. The duration of 'thinking' time is known as processing speed. Processing speed has to do with how quickly a person is able to carry out simple or automatic cognitive tasks; usually this is measured under time pressure such that a degree of focused attention is involved. Other brain functions such as

perception and motivation also come into play in order for a person to exhibit good processing speed. Processing speed is one of four psychometric constructs that are considered important in helping us understand an individual child's learning abilities. (The other three are verbal comprehension abilities, nonverbal reasoning abilities, and working memory.) There are also other elements – such as language, memory, and executive functions, among others - that are important in this regard, as well. For some people, problems with processing speed can be coupled with a generally slow tempo; these are people who move through the world at a slower pace in much or all of what they say or do. The Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV, 2008), defines Processing Speed Index as- *the abilities to focus attention and quickly scan, discriminate between, and sequentially order visual information. It requires persistence and planning ability, but is sensitive to motivation, difficulty working under a time pressure, and motor coordination.* In addition, children with attentional problem typically exhibit poor executive functions, brain-based behaviours that contribute to effective functioning. A useful model of executive functions has been developed by Brown (2001). The functions proposed are activation, focus, effort, emotion, memory and action. Here 'Effort' includes processing speed as well as mental stamina. When effort is a problem, the child's work pace is very slow, on the other hand, he might find it hard to regulate his feelings. He might melt down when starting to work or encountering a frustrating task; or they may refuse to work, be argumentative, or have tantrums. Thus, this model tries to link the Processing Speed Index with the Executive functioning in case of children and adults (Brown, 2001).

Ways that processing speed can be involved in a child's daily functioning include being able to quickly and easily: take tests or do tasks that involve simple decision-making; copy words or sentences correctly (i.e., note-taking); manipulate numbers and make simple arithmetic computations; recognize simple visual patterns; read passages silently for comprehension; make decisions that involve understanding of material that has been presented (in any modality); carry out reasoning tasks under a time demand; and keep up with the flow and comprehension of conversations between people. The Working Memory Index (WMI) and the Processing Speed Index (PSI) - can be summarized in the Cognitive Proficiency Index (CPI). The CPI refers more

to underlying abilities that contribute to the efficiency and proficiency with which a person responds to cognitive tasks.

1.1.4 REASONING SKILLS

The ability to reason independently from one's own goals or beliefs has long been recognised as a key characteristic of the development of formal operational thought. According to a number of theorists a hallmark of formal reasoning competence is the ability to reason logically from a series of premises. The ability to reason independent of one's own beliefs is widely viewed as a core cognitive ability that underlies the development of critical and analytic thinking skills (Pithers & Soden, 2000). Two aspects of cognitive processing consistently predict reasoning performance viz., (i) cognitive ability and (ii) thinking style (Stanovich, 1999). Cognitive ability is assumed to reflect the capacity of a processing or working memory system, while thinking style is a personality-based measure that reflects such things as openness to ideas, considerations of alternatives, and cognitive flexibility. That is reasoning depends both on how well an individuals cognitive abilities function and also on his personality, idealogies and beliefs. Thus, cognitive ability also called the explicit system is linked to deductive reasoning, novel problem solving, and intelligence, whereas, the thinking style or implicit system is associated with belief-based, pragmatic, language-based processes. At times we are outrun by our beliefs and idealogies even when they may be wrong. In order to perform accurately on such problems, a complete logical analysis is needed. And it is how well one reasons one's beliefs is the very soul of good reasoning skills. Reasoning skills are one of the core skills required to live a successful life because the environment is underlying with an array of factors some favour your goal while others don't. It is for the same that Reasoning skills play an important role as these eventually analyse and reason out the arrays important for goal achievement and neglects the other. This component as a cognitive ability is called as Inhibition an important component of Executive functioning. Handley et al., (2007) have also inferred a positive correlation of Reasoning skills with the two important components of Executive functioning, i.e., Inhibition and Working Memory. The research by Attridgea, Doritoub and Inglisc (2015) showed high correlation of Reasoning Skills

with math education and shows that good reasoning skills out perform a person's numeral capacities. Thus, highlighting the significance of Reasoning Skills in dealing with students with Dyscalculia.

1.2 EMERGENCE OF THE PROBLEM

Children's underachievement in mathematics is a consistent and significant problem (Dowker, 2009). These problems endure into adulthood, and it is estimated that a fifth of adults have numeracy skills below the basic level needed for everyday situations (William et al., 2003). Mathematics ability is crucial for success and poor mathematics skills have a bigger impact on life chances than poor literacy (Parsons & Bynners, 2005). Many factors contribute to differences in mathematics achievement, including attitudes, motivation, language ability and IQ, in addition to social, and educational factors. It is clear that domain-specific numerical skills and knowledge are important for success with mathematics (Gilmore et al., 2010), but other cognitive factors also play an important role. In particular, the domain-general skill of holding and manipulating information in mind (working memory) has been found to be critical (Raghubar, 2010). Inhibition-the ability to suppress distracting information and unwanted responses, and shifting, the ability to flexibly switch attention between different tasks, have also been implicated in mathematics achievement (Rebecca & Gaia, 2001). These processes fall under the umbrella of Executive function (EF); skills required to monitor and control thought and action. Thus, these process have a significant connect with Mathematics.

But the situation takes a grim route when it comes to students who have yet another genetic learning disability to follow in Mathematics, i.e., Dyscalculia. Dyscalculia is a specific learning disability which affects six percent of the population. Dyscalculics are not unintelligent students but struggle to learn mathematics and mathematics related learning concepts (such as quantity, place value, and time), difficulty memorizing math facts, difficulty organizing numbers, and understanding how problems are organized on the page but still have a normal or above normal IQ (Shalev & Gross-Tsur, 2001; Butterworth, 2003). The lack of anticipation ability in mathematics interferes with educational performance or daily activities and these problems are

widespread than neural and sense defects. Moreover, students with dyscalculia have problems in linguistic, perceptual, cognitive and behavioural skills. Children with dyscalculia fall behind early in primary school and may develop stress, anxiety and low self-esteem. In secondary school they find difficulty in passing mathematics and science courses and as they grow they face limited career options and low income compared to their peers.

These constraints are due to their restrained cognitive processes which include Processing Speed, Reasoning Skills and Problem-solving skills. Processing speed determines ones quick scan and focus abilities and sequentially order visual information. Demetriou et al. (2002) reported the evidence for direct and indirect links between processing speed and reasoning respectively. And it is only with the efficiency of these cognitive process one can aim to develop and master the Problem- solving Skills. Children process information at different speeds and showcase different patterns of reasoning and Problem-solving abilities. Studies have shown lower graph considering these skills in case of Dyscalculics as compared to their peers. Executive function shows a considerable association with Processing Speed Index as presented by Brown (2001) and Cepada, Blackwell and Munakata (2013).Varied Processing Speeds are seen in case of students with Learning Disability and those without them (Moll et al., 2014). Therefore it becomes important to analyse researches in both the Indian and International scenario in reference to the intended variables of study. But first its important to understand the scenario at home.

Table 1.4 Exhibiting the Review of Researches in reference to the Variables of Study in the Indian Context

SN	Researchers ↓ / Variables of the Study →	Problem-solving Skills	Processing Speed	Reasoning Skills	EF	Dyscalculia	Sample of the Study	Results
1	Bhatia, et al. (2009)				✓		172 Schizophrenic patients & 196 patients	Patients and their parents showed more cognitive impairments than controls
2	Chavan, et al. (2013)					✓	Dyscalculic students	Relation of Dyscalculia & comorbidity

Cont'd..

3	Chavan & Gaikwad (2015)		✓				Qualitative study	Vedic maths enhances the digital signal processing speed
4	Kelkar, et al. (2013)				✓		22 Indians & 20 Americans	Differences of Eastern & Western cultures on EF
5	Modi, et al. (2015)			✓			Qualitative Study	Emphasis on clinical reasoning in medical schools
6	Sarasani (2008)			✓			200 students from Hyderabad city	Boys performed better in reasoning skills compared to girls
7	Senthamarai Kannan, et al. (2016)	✓					80 ninth graders	The level of problem solving in mathematics was average
8	Sharma (2015)	✓					211 adolescent children aged 13-16 years	Problem solving training is a positive indicator of good resilence
9	Sherafat (2015)			✓			625 students from Mysore city	Reasoning skills as indicator of positive achievement
10	Sinha, et al. (2008)				✓		Students with ADHD	Deficits in EF maybe central feature of ADHD
11	Sharma & Ahuja (2015)				✓		200 adolescents in the age group of 13-19 years	Positive correlation between Consciousness Quotient & 2 EFs
12	Purohit, et al. (2017)				✓		72 healthy orphan adolescents	Yoga helps improve EF
13	Ramaa & Gowramma (2002)					✓	40 Primary School Dyscalculic Students	Proposed measures of identification of Dyscalculia
14	Vashistha & Gupta (2016)					✓	Dyscalculic students	Significant effect of Predicting parameters on Dyscalculic co-morbidity
15	Vashistha & Bapte (2016)		✓		✓	✓	40 Elementary Dyscalculic students	Processing speed index & Working memory as determinants of EF in Dyscalculics
16	Vashistha & Bapte (2016)					✓	Dyscalculic students	Life Skills Training positively affects decision-making of Dyscalculics

The mapping of the studies in the above table gives a glimpse of the researches done in the Indian context then majority of the studies done in reference to Dyscalculia do not work in reference to the interested variables of study except Vashistha & Bapte (2016)

Table 1.5: Exhibiting the Review of Researches in reference to the Variables of Study

SN	Researchers ↓ / Variables of Study →	Problem-solving Skills	Processing Speed	Reasoning Skills	EF	Dyscalculia	Sample of the Study	Results
1	Aarnoudse-Moens, et al. (2013)				✓		Preterm Children	EF predicts Math problems in very Pretern children
2	Bellaj, Salhi, Legall, & Roy. (2015)				✓		School- aged Tunisian children	EF develops faster in school age population
3	Benson & Sabbagh (2013)				✓		Large Multinational Firm	EF and social cognition have high relation
4	Bilac, Mcleod, & Gobet (2009)	✓					Expert chess players	Study of Processing Speed of Chess players
5	Bull, Espy & Wiebe (2008)				✓		Pre- schoolers of 7 year	EF is a longitudinal predictor of math ability
6	Butterworth (2003)					✓	Students with Developmental Dyscalculia	Dyscalculia is a genetic disability
7	Cepeda, Blackwell &Munakata (2013)		✓		✓		A longitudinal study on sample of 6-85 year olds	Positive relation between Processing Speed & EF
8	Chia (2014)					✓	American and Singaporean students with Dyscalculia	The cognitive processes in American was higher than Singaporean Dyscalculics
9	Cornoldi,et al.,(2015)	✓					Primary School students	Improving the problem-solving skills through a training programme
10	Farrington-Flint et al., (2009)	✓					Students	Study of Problem-solving pattern on Math
11	Fuchs et al., (2002)	✓				✓	Students with mathematics learning disability	Poor Problem-solving in Math LDs
12	LaRosa, Thomas (2015)		✓			✓	Learning Disables of 3-8 grades	Low Processing in LDs in comparison to their peers
13	Kail, Lervag & Hulme (2015)		✓		✓		277 students of 6-13 year old	Variations in Processing Speed effects Reasoning
14	Morsanyi et al.,(2013)			✓		✓	Dyscalculic population	Low Reasoning abilities in Dyscalculics

Cont'd...

15	Irwin, Casey Marie (2013)				✓		Students of kindergarden	Positive relation of EF with Math achievement
16	Momeni et al., (2012)					✓	Afgani Dyscalculic School-going Students	Study of social & emotional competence of Dyscalculics
17	Mclean & Hitch (1999)					✓	Students with Specific Arithmetic Learning Difficulties	Slow Working memory in Student with Math LD
18	Moll et al., (2014)		✓			✓	Students with Specific Learning Disorder	Having varied Processing Speed in LDs
19	Mourtos, Okamato & Rhee (2004)			✓			Students of Engineering	Reasoning skills as predictor of good engineering skills
20	Narimani et al., (2014)				✓	✓	Students with Dyscalculia	EF intervention improves Working Memory in Dyscalculics
21	Swanson & Sachse-Lee (2001)	✓			✓		8-11.5 year students with LD	Low Problem-solving skills and EF in LDs
22	Toll, Van der Vel, Kroesbergen &Van Luit (2011)				✓	✓	First and Second Grade students with Math LD	The EF skill Working Memory predicted Math LD
23	Wittlin, & Noam (2010)				✓	✓	Adults with mathematics learning disorder	Showed less EF in adults with Dyscalculia
24	Zimmermann, Ute (2008)		✓			✓	College students with diverse ethnic background	Ethinicity causes difference in Processing Speed in Math and other LDs

The above-mentioned researches highlight that studies in reference to Executive functioning highlight only its importance and relation with Mathematics Achievement in both Adults and children (Aarnoudse-Moens, et al., 2013 and Bellaj, Salhi, Legall, & Roy, 2015). But, when it comes to the researchers on Executive functioning and Dyscalculia a very few researchers and many researches tend to study Dyscalculia. Moreover when visualize in terms of study's variables only one- two studies are found dealing with variables of Working memory and Executive functioning in reference to Working memory, a subcomponent of Executive functioning which further limits the literature. Processing Speed Index and Executive functioning and similar is the case with researches on Problem-solving Skills and Reasoning Skills. The researches are majorly

linked with Mathematics as a discipline but only few cater to the advancement and research in the field of Dyscalculia. The scope of these variables are largely explored in the neuropsychological and pure neuroscience dimensions, too. Whereas, the strata of exploration are less delved in the Indian context. Thus, it is important to study and understand deeply the executive functions of students with Dyscalculia and to research it in the context of Problem-solving Skills, Processing Speed Index and Reasoning Skills.

1.3 STATEMENT OF THE PROBLEM

Viewing the facts available in explored researches the researcher has identified her Problem which can be stated as below:

Problem- solving Skills, Processing Speed Index and Reasoning Skills as the determinants of the Executive Functioning of students with Dyscalculia

1.4 OPERATIONAL DEFINITIONS OF THE TERMS EMPLOYED IN THE STUDY

The various terms used in the statement of problem have different connotations for different people. To make these meaningful in present context, the operational definitions can be given as follows:

1. **Problem-solving Skills**

Sezetela & Nicol (1992) defined Problem-solving as the process of confronting a novel situation formulating connections between given facts, identifying the goal and exploring possible strategies for reaching the goal.

The researcher tends to use the POWER Model(1999) of Problem-solving where it is important to firstly identify and state the problem, think of different options that can be used to solve the Problem. Then to skilfully analyse each option and chosen option the one with the least demerits and then to reflect on the choice once made.

2. Processing Speed Index

Processing Speed Index as defined in Wechsler Intelligence Scale for Children-IV (2008) - the abilities to focus attention and quickly scan, discriminate between, and sequentially order visual

information. It requires persistence and planning ability, but is sensitive to motivation, difficulty working under a time pressure, and motor coordination.

In the light of the above definition the researcher tends to evaluate the Processing Speed Index of the students with Dyscalculia by incorporating the three dimensions as proposed by Wechsler (2008) (i) coding (transcribe symbols using a code), (ii) symbol search (mark weather a target symbol occurs in a search group) and (iii) cancellation (mark target members of a category mixed in arrays of targets).

3. Reasoning Skills

Lohman & Lakin (2009) defined Reasoning skills as the ability to infer (either automatically or deliberately) concepts, patterns, or rules that best (i.e., most uniquely) characterize the relationships or patterns they perceive among all the elements (e.g., words, symbols, figures, sounds, movements) in a stimulus set and to deduce the consequences or implications of a rule, set of premises, or statements using warrants that are rendered plausible by logic or by information that is either given in the problem or assumed to be true within the community of discourse.

In the present study the researcher will evaluate the Reasoning skills of the students with Dyscalculia by incorporating the stimulus sets to infer the possible concepts and patterns and to also deduce the set of premises which will be given in the problem. Thus, Reasoning Skills in the present study is a balanced combination of the ability to do both Inductive and Deductive reasoning.

4. Executive Functioning

Executive Function (EF) refers to brain functions that activate, organize, integrate and manage other functions. It enables individuals to account for short and long term consequences of their actions and to plan for those results. It also allows individuals to make real time evaluations of their actions, and make necessary adjustments if those actions are not achieving the desired result.

The present research studies Executive functioning as a component of seven sub-components of Cognitive flexibility (the mental ability to switch between two different concepts and to think about multiple concepts simultaneously), Planning (the process of thinking about and organizing the activities required to achieve a desired goal), Inhibition (neglecting the unwanted stimuli from the environment which hinder the goal), Organisation (recognizing the right pattern and sequencing the information in the right order), Visual- processing (ability to spatial problems), Verbal fluency (the ability to form and express words compatible with required criteria) and Concept formation (an inductive strategy which forms a clear understanding of a concept through a set of examples) as recognized by Zimmermann(2008) and the Delis-Kaplan Test(2002).

5. Dyscalculia

The operational definition for the present study as propounded by Department of Education and Skills (2001) defines Dyscalculia as, a condition that affects the ability to acquire arithmetic skills. Dyscalculic learners may have difficulty understanding simple number concepts, lack an intuitive grasp of numbers, and have problem learning number facts and procedures. Even if they produce a correct answer or use a correct method, they may do so mechanically and without confidence.

1.5 OBJECTIVES OF THE STUDY

The objectives for the present research study can be laid down as below:

1. To study the independent effect of Predicting variables (Problem-solving skills, Processing Speed Index and Reasoning Skills) on the Executive functioning of students with Dyscalculia.
2. To examine the interaction effect of two Predicting variables (Problem-solving skills and Processing Speed Index) on the Executive functioning of students with Dyscalculia.
3. To examine the interaction effect of two Predicting variables (Problem-solving skills and Reasoning Skills) on the Executive functioning of students with Dyscalculia.
4. To examine the interaction effect of two Predicting variables (Reasoning Skills and Processing Speed Index) on the Executive functioning of students with Dyscalculia.

5. To examine the joint interactional effect of Predicting variables (Problem-solving skills, Processing Speed Index and Reasoning Skills) on the Executive functioning of students with Dyscalculia.
6. To predict the relative contribution of Predicting variables (Problem-solving skills, Processing Speed Index and Reasoning Skills) on the Executive functioning of students with Dyscalculia.
7. To provide the remedial intervention programme to students with Dyscalculia.
8. To examine the effect of remedial intervention programme on the Executive functioning of students with Dyscalculia.

1.6 HYPOTHESES OF THE STUDY

In the context of the above-mentioned objectives of the study the null hypotheses are formulated as under:

Ho_1: There exists no significant effect of Predicting variables (Problem-solving skills, Processing Speed Index and Reasoning Skills) on the Executive functioning of students with Dyscalculia.

Ho_2: There exists no significant interaction effect of two Predicting variables (Problem-solving skills and Processing Speed Index) on the Executive functioning of students with Dyscalculia.

Ho_3: There exists no significant interaction effect of two Predicting variables (Problem-solving skills and Reasoning Skills) on the Executive functioning of students with Dyscalculia.

Ho_4: There exists no significant interaction effect of two Predicting variables (Reasoning Skills and Processing Speed Index) on the Executive functioning of students with Dyscalculia.

Ho_5: There exists no significant joint interactional effect of Predicting variables (Problem-solving skills, Processing Speed Index and Reasoning Skills) on the Executive functioning of students with Dyscalculia.

Ho_6: Predicting variables are not contributing significantly in the prediction of Executive functioning of students with Dyscalculia.

Ho_7: There is no effect of remedial intervention programme on the Executive functioning of Students with Dyscalculia.

1.7.0 METHODOLOGY OF THE STUDY

The method of the study is Descriptive-cum-Quasi-Experimental which is divided into four distinct phases as discussed below:

PHASE I: This phase of the research primarily involves the identification of students with Dyscalculia in Agra city.

PHASE II: This phase involves assessing the Problem-solving Skills, Processing Speed Index Reasoning Skills and Executive functioning of the students with Dyscalculia in Agra city.

PHASE III: This phase comprises the preparation of the remedial intervention programme on Problem-solving Skills, Processing Speed Index and Reasoning Skills of Students with Dyscalculia will be incorporated. Then the researcher will divide the students with Dyscalculia sample into Experimental and Control group by randomization. Remedial intervention programme on Problem-solving Skills, Reasoning Skills and Processing Speed Index will be implemented on the Experimental group.

PHASE IV: The final phase will deal with the study to determine the effect of remedial intervention programme on Problem-solving Skills, Processing Speed Index and Reasoning Skills in relation to Executive functioning of students with Dyscalculia.

1.7.1 VARIABLES OF THE STUDY

The variables involved in the present study can be summarized as following:

1) Criterion/Dependent Variable: Executive functioning

2) Predictive/ Independent Variables: (i) Problem-solving Skills,
(ii) Processing Speed Index
(iii) Reasoning Skills

3) Control Variables: Students with Dyscalculia, Grades VI- VIII.

1.7.2 SAMPLE OF THE STUDY

The sample of the study will be selected in accordance to the phases outlined below:

PHASE I: Selection of Schools

The CBSE and ICSE schools of Agra city will be selected for the identification of the students with Dyscalculia. The random sampling technique will be used to select at least ten schools from the given number of seventy eight CBSE and ICSE schools in Agra.

PHASE II: Selection of Sample

From the randomly selected schools, researcher will identify the students with Dyscalculia with the help of the Dyscalculic Identification Scale by Vashistha & Gupta (2014). The identification scale will be administered in classes VI-VIII of these randomly selected schools. Once the actual sample of fifteen hundred students with Dyscalculia will be identified the remaining tools of Executive functioning, Problem-solving skills, Processing Speed Index and Reasoning Skills will be administered on the identified sample of students with Dyscalculia.

PHASE III: Purposive Sampling

The researcher will purposively select the school with higher number of students with Dyscalculia for conducting for intervention programme. The students with Dyscalculia will be randomly divided into two separate groups of Experimental and Control. The remedial intervention program will be administered on the Experimental group. After the completion of the remedial intervention programme the reason the Executive functioning will be re-administered to both the Experimental and Control group.

1.7.3 DELIMITATION OF THE STUDY

The present research will be delimited in terms of the following:

1. The study will be delimited only to the CBSE & ICSE schools in reference to the jurisdiction of Agra city.

2. The study will involve students with Dyscalculia only from the Grades of VI to VIII.

1.7.4 TOOLS TO BE EMPLOYED

The researcher will employ the following tools to determine the Executive functioning of students with Dyscalculia in reference to Problem-solving Skills, Processing Speed Index and Reasoning Skills:

1. Dyscalculic Identification Scale developed by Vashistha and Gupta (2014). It is a 35 item tool to screen the students with Dyscalculia having a Cronbach Alpha Reliability of 0.886.
2. Self-constructed tools for Executive Functioning, Problem-solving Skills, Processing Speed Index and Reasoning Skills.
4. Self-developed remedial intervention programme on Problem-solving Skills, Processing Speed Index and Reasoning Skills.

1.7.5 STATISTICAL DESIGN OF THE STUDY

The researcher will use both Descriptive (Mean and Standard deviation) and Inferential (One-way ANOVA, Paired t- test and Multiple Linear Regression Analysis) Statistics. Following are the Statistical techniques at a glance arranged in order of the Hypothesis testing in the present research:

Table 1.6: Statistical Pre-view of Research Design

SN	Nature of Statistical Treatment	Where to Apply
1	**Descriptive Statistics**	
(i)	Mean and Standard Deviation, Skewness/Kurtosis and Q-Q Plots	For consolidating and operating complete data on different DV and IVs and for testing the Normalcy of the Data
2	**Inferential Statistics**	
(i)	One-way ANOVA	Null Hypothesis No. 1
(ii)	Two-way ANOVA	Null Hypothesis No. 2 Null Hypothesis No. 3 Null Hypothesis No. 4
(iii)	Three-way ANOVA	Null Hypothesis No. 5
(iv)	Multiple Linear Regression Analysis	Null Hypothesis No. 6
(v)	Paired t-Test	Null Hypothesis No. 7

1.8 SIGNIFICANCE OF THE STUDY

Today we live in a world of challenges which can be converted into the desired opportunities if one has the right skill to do so. These challenges become all the more challenging for students with learning disabilities. The world runs around the number game. Good numeracy skills are important for being a successful member of the society. Bad numeracy skills are a handicap than poor literacy skills when it comes to getting a job, maintain a job and being promoted within employment. Keeping this in view a learning disorder related to Mathematics makes the situation all the more gross. Thus, students with Dyscalculia when enter this demanding world are somewhat slow paced when compared to their peers. They face problems in day to day simple calculations and skills required to take decisions. Hence in the long run they fall victim to anxiety, low self-esteem and depression.

Executive functions play a vital role and have a significant relation with the numerical ability. The students with dyscalculia are said to have problems the managing the various cognitive processes. They lack behind their peers because low working memory and processing speed index. Both working memory and processing speed are interrelated with executive functions. Hence, if these students are helped regarding the enhancement of theses major components it will lead to the efficient execution and management of these cognitive processes. It is the cognitive abilities that keep the students with Dyscalculia from true progress.

Hence, it becomes all the more important to deal with their day to day inefficiency at various tasks not just numerical tasks in general. It's important to identify their prevalence rate of the students with Dyscalculia at the Elementary level and then to assess the Executive functioning.

Then its important to examine the effect Problem- solving Skills, Processing Speed Index and Reasoning Skills have on Executive functioning of the students with Dyscalculia. The major task at hand is to provide a remedial intervention for bringing about an improvement in Problem-solving Skills, Processing Speed Index and Reasoning Skills of these mathematics learning disables. As Dyscalculia is a genetic disorder and cannot be cured one cannot wait for the

conditions to worsen. But an immediate need arises to intervene from the very beginning. Its crucial that the parents, teachers and policy-makers help these students to be successful to make appropriate decisions. Therefore this endeavour of the researcher to assess the effect of Problem-solving Skills, Processing Speed Index and Reasoning Skills of students with Dyscalculia and to improve them to bring about a constructive difference in the Executive functioning of the students with Dyscalculia. Which in turn can help the policy makers and curriculum constructors better understand the students with Dyscalculia and include the components which enhance their Executive functioning in the very curricula. Thus its greatest benefit making life happy and a bit easy in the long run for the already strenuous life that these students lead in the world.

REFERENCES

Aarnoudse-Moens, C., Weisglas- Kuperus, N., Duivenvoorden, H., van Goudoever, J., & Ooterlaan,J. (2013). Executive function and IQ predict mathematical and attention problem in very preterm children. *PLoSONE, 8(2).*doi: 10.1371/ journal. Pone.0055994

Barahmand, U. (2008). Arithmetic disabilities: Training in attention and memory enhances arithmetic ability. *Research Journal of biological Sciences, 3(11),* 71-92.

Bhatia, T., Garg, K., Pogue-Geile, M., Nimgaonkar, V. L., & Deshpande, S. N. (2009). Executive functions and cognitive deficits in schizophrenia: comparisons between probands, parents and controls in India. *Journal of postgraduate medicine, 55(1),* 3.

Bilalic, M., Mcleod, P., & Gobet, F. (2009). Specialization effect and its influence on memory and problem- solving in expert chess players. *Cognitive Science, 33,* 1117-1143.

Bull, R., Espy, K., & Wiebe, S. (2008). Short-term memory, working memory, and execution functioning in pre- schoolers: Longitudinal predictors of mathematical achievement at age 7 years. *Developmental Neuropsychology, 32(5),* 455462. doi:10.1080/1380339031 64363

Bull, R., & Scerif, G. (2010). Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working Memory. *Developmental Psychology, 19(3),* 273-293. doi: 10.1207/S1535269942DN1903_3

Burgess, P. W., Veitch, E., de lacy Costello, A., & Shallice, T. (2000). The cognitive and neuroanatomical correlates of multi-tasking. *Neuropsychologia, 38,* 848-863.

Butterworth, B. (2003). Dyscalculia Screener. London: Nelson Publishing Company Ltd

Butterworth, B. (2005). Developmental Dyscalculia. In J.I.D. Campbell (Ed.), *Handbook of Mathematical Cognition* (pp. 455-468). New York: Psychology Press.

Cepeda, J. N., Blackwell, A. K., & Munakata, Y. (2013). Speed isn't everything: Complex processing speed measures mask individual differences and developmental changes in executive control. *Developmental Science, 16(2),* 269-286. doi:10.1111/desc.1204

Chan, C. K. R., Shum, D., Touplopoulou, T., & Chen, Y. E. (2008). Assessment of executive functions: Review of instruments and identification of critical issues. *Archives of*

Clinical Neuropsychology, 23, 201-216. doi:10.1016/j.acn.2007.08.010

Arun, P., Chavan, B. S., Bhargava, R., Sharma, A., & Kaur, J. (2013). Prevalence of specific developmental disorder of scholastic skill in school students in Chandigarh, India. *The Indian journal of medical research, 138(1),* 89.

Chia, H. K. N. (2014). A comparison of cognitive equations of mathematics learning process between the American and Singaporean students with dyscalculia. *Educational Research international, 3(1).* Cornoldi, C., Carretti, B., Drusi, S., & Tencati, C. (2015). Improving problem- solving in primary school students: The effect of a training programme focusing on metacognition and working memory. *The British Psychological Society, 85(3),* 424-439.doi: 10.1111/bjep.12083

Cragg, L., & Gilmore, C. (2014). Skills underlying mathematics: The role of executive functioning in the development of mathematics proficiency. *Trends in Neuroscience and Education, 3,* 63- 68. doi:10.1016/j.tine.2013.12.001

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4-12 years old. *Science, 333(6045),* 959-964. doi:10.1126/science.1204529

Diesfeldt, F. H. (2004). Executive functioning in psychogeriatric patients: scalability and construct validility of the behavioural dyscontrol scale (BDS). *International Journal of Geriatric Psychaitry, 19,* 1065-1073. Doi:10.1002/gps.1212

Dovis, S., Vander Oord, S., Wiers, W. R., & Prins, J. P. (2015). *Improving executive functioning children with adhd:* Training multiple executive functions within the context of a computer game. A randomized double blind placeo controlled trail. *PLOS.* doi:10.1371/journal.pone.0121651

Farrington- Flint, L., Vanuxem-Cotterill, S., & Stiller, J. (2009). Patterns of problem- solving in children's literacy and arithmetic. *British Journal of Developmental Psychology, 27,* 815-834.

Fuchs, S. L., Fuchs, D., Hamlett, L. C., & Appleton, C. A. (2002). Explicitly teaching for transfer: Effects on the mathematical problem- solving performance of students with mathematics disabilities. *Learning Disabilities Research and Practise, 17(2),* 90-106.

Gaikwad, K. M., & Chavan, M. S. (2015). Vedic Mathematics for Digital Signal Processing Operations: A Review. International Journal of Computer Applications, 113(18).

Geary, C. D., Hamson, C. O., & Hoard, M. K. (2000). Numerical and arithmetical cognition: a longitudinal study of process and concept deficits in children with learning disability. *Journal of Experimental Child Psychology, 77,* 236-263.

Geary, C. D., Bailey, D. H., Littlefield, A., wood, P., Hoard, M. K., & nugent, L. (2009). Firstgrade predictors of mathematical learning disability: A latent class trajectory analysis. *Cognitive Development, 24(4),* 411-429.

Ghassabian, A., Herba, M. C., Roza, J. S., Govaert, P, J.S., Jaddoe, W. V., Hofman, A.,…Tiemeier, H. (2013). *Journal of Child Psychology and Psychiatry, 54(1),* 96-104.

Gilbert, J. S., & Burgess, W. P. (2012). Executive function. *Current Biology, 18(3).*

Gross- Tsur, V., Manor, O., & Shalev, S. R. (2008). Developmental dyscalculia. *European Child adolescent Psychiatry, 9(2),* 1158-1164.

Isquith, K. P., Crawford, S. J., espy, A. K., & Gioia, A. G. (2005). Assessment of executive function in pre-school- aged children. *Mental Retardation and developmental disabilities, 11,* 209-215.

Kail, V. R., Lerva, A., & Hulme, C. (2015). Longitudinal evidence linking processing speed to the development of reasoning. *Developmental Science,* 1-8. doi:10.1111/desc.12352

Kazemi, R., Momeni, S., & Abolghasemi, A. (2004). The effectiveness of life-skills training on self-esteem and communication skills of students with dyscalculia. *Procedia-Social and Behavioural Sciences, 114,* 863-866.

Kroesbergen, H. E., & Dijk, van., M. (2003). Redefining learning disabilities as inadequate response to instruction: The promise and potential problems. *Learning Disabilities Research and Practise, 18(3),* 137-146.

Kosc, L. (1974). Developmental dyscalculia. Journal of Learning Disabilities, 7, 159-162.

LaRosa, T. J. (2015). Correlational evidence between the processing speed index, coherent motion threshold, and achievement scores of children with and without learning disabilities (3705184).Retrieved from http://search.proquest.com/docview/1690904273?accountid=50773

Latzman, D.R., Elkovitch, N., Young, J., & Clark, L. (2010). The contribution of executive functioning to the academic achievement among male adolescents. *Journal of Clinical and Experimental Neuropsychology, 32(5),* 455-462. doi: 10.1080/13803390903164363

Laxmi, V. (2009). The prevalence of specific learning disabilities among primary school children of Belgaum city: A cross sectional city (Doctoral dissertation, K. L. E University, Belgaum, Karnataka).Retrieved from http://182.48.228.18:8080/jspui/bitstream/123456789/636/1/VIJAYLAXMI.pdf

Lee, K., Ng, S., LeePe, M., Ang, S., Hasshim, M., & Bull, R. (2012). The cognitive underpinnings of emerging mathematical skills: Executive functioning, patterns, numeracy, arithmetic. *British Journal of Educational Psychology, 82,* 82-89. doi:10.1111/j.2044-8279.2010.02016.x

Lindsay, L. R., Tomazic, T., Levine, D. M., & Accardo, J. P. (1999). Impact of attentional dysfunction in dyscalculia. *Developmental medicine and Child Neurology, 41,* 639-642.

Modi, J. N., Gupta, P., & Singh, T. (2015). Teaching and assessing clinical reasoning skills. *Indian pediatrics, 52(9),* 787-794. Chicago

Momemi, S., Brak, M., Kazemi, R., Abolghasemi, A., Babari, M., & Ezati, F. (2012). Study of the effectiveness of the social skills training on the social and emotional competence among students with mathematics learning disorder. *Scientific Research, 3(8),* 13071310.

Morsanyi, K., Devine, A., Nobes, A., & Szűcs, D. (2013). The link between logic, mathematics and imagination: Evidence from children with developmental dyscalculia and mathematically gifted children. Developmental science, 16(4), 542-553.

Missier, D. F., Mantylaa, T., & Bruine de Bruin, W. (2011). Decision-making competence, executive functioning, and general cognitive abilities. *Journal of Behavioural Decision-making, 25,* 331-351. doi:10.1002/bdm.731

Miyake, A., Freidman, P. N., Rettinger, A. D., Shah, P., & Hegarty, M. (2001). How are visuospatial working memory, executive functioning, and spatial abilities related? A latent- variable analysis. *Journal of Experimental Psychology, 130(4),* 621-640.doi:10.1037//0096-3445.1340.4.621

Moll, K., Gobel, M. S., Govch, D., Landerl, K., & Snowling, M. (2014). Cognitive risk factors for specific learning disorder processing speed, temporal processing and working memory. *Journal of Learning Disabilities.* doi:10.177/0022219414547221

Moll, K., Kunze, S., Neuhoff, N., Bruder, J., & Schutte-Korne, G. (2014). Specific learning disorder: Prevalence and gender differences. *PLoSONE.* doi:10.1371/journal.pone.0103537

Mourtos, J. N., Okamoto, N., & Rhee, J. (2004). Defining, teaching and assessing problemsolving skills. *Annual Conference on Engineering Education,* 9-13.

Narimani,M.,Abbasi,M.,& Ahadi, B. (2013). The effectiveness of training acceptance/commitment and training emotion regulation of high-risk behaviours of students with dyscalculia. *International Journal of high Risk Behaviour Addiction, 2(2),* 51-58.doi:10.5912/ijhrba.10791

Narimani, M., Soleymani, E., Babolan, Z. A., & Abolghasemi, A. (2014). The comparison of the effectiveness of executive functionals and play therapy on improving of working memory, attention care and academic achievement in students with math learning disorder. *Journal of Clinincal Psychology, 5(4),* 116. Retrieved from http://jcp.semnan.ac.ir/browse.php?a_c ode=A-10-247-45&slc-lang=en&sid=1

Pina, V.,& Diamantopoulou, S. (2014). Disentangling the effects of working memory, language, parental education, and non-verbal intelligence on children's mathematical abilities. *Frontiers in Psychology, 5,* 415. doi:10.3389/fpsyg.2014.00415

Price, G. R., & Ansari, D. (2013). Dyscalculia: Characteristics, causes, and treatments. *Numeracy, 6(1).* doi:10.5038/1936-4660.6.12

Price, G. R., Holloway, I., Rasanen, P., Vesterinen, M., & Ansari, D. (2007). Impaired parietal magnitude processing in developmental dyscalculia. *Current Biology, 17(24),* 1042-1043.

Purohit, S. P., & Pradhan, B. (2017). Effect of yoga program on executive functions of adolescents dwelling in an orphan home: A randomized controlled study. *Journal of Traditional and Complementary Medicine, 7(1),* 99-105.

Ramma, S., & Gowramma, I. P. (2002). A systematic procedure for identifying and classifying children with dyscalculia among primary school children in India. *Dyslexia, 8,* 67-85.

Sayarifard, A., Mohseny, M., & Montazer, M. (2013). Assess the efficacy of teaching life skills on the social competence of students with dyscalculia hepatitis. *International Research Journal of Applied and basic sciences, 6(11),* 1681-1685.ISSN 2251-838x

Senthamarai Kannan, B., Sivapragasam, C., & Senthilkumar, R. (2016). A study on problem solving ability in mathematics of IX standard students in Dindigul district. IJAR, 2(1), 797-799.

Sharma, S., & Ahuja, S. (2016). CONSCIOUSNESS QUOTIENT AS A PREDICTOR OF EXECUTIVE FUNCTIONING. MIER Journal of Educational Studies, Trends and Practices, 5(2).

Shalev, R. (2004). Developmental dyscalculia: Review. *Journal of Child neurology, 19(10),*

765-771.

Sherafat, R. (2015). Critical Thinking, Reasoning, and Logical Concluding' Abilities in relation to Academic Achievement among Indian Adolescent Students.

Titz, C., & Karbach, J. (2014). Working memory and executive functions: Effects of training on academic achievement. *Psychological Research, 78(6),* 852-868.

Tosto, G. M., Hanscombe, B. K., Haworth, M.A. C., Davis, S. P., Petrill, A., Dale, S.P.,…& Kovas, Y.(2014). Why spatial abilities predict, mathematical performance? *Developmental Science, 17(3),* 462-470. doi:10.1111/desc.12138

Vashistha, K. & Bapte, A. (2016). The Efficacy of life skills training on decision-making skills of students with dyscalculia. Journal of Indian Education.

Vashistha, K. & Bapte, A. (2016). Processing speed index and working memory as determinants of executive functioning in dyscalculics (Unpublished M.Phil. Dissertation). Dayalbagh Educational Institute, Agra.

Vashistha, K. & Gupta, N. (2016). Dyscalculic Co-morbidity in Secondary School-going children:A comprehensive study of predicting parameters and remedies (Unpublished doctoral Dissertation). Dayalbagh Educational Institute, Agra.

Vaughn, S., & Fuchs, S. L. (2003). Redefining learning disabilities as inadequate response to instruction: The promise and potential problems. *Learning Disabilities Research and Practise, 18(3),* 137-146

Zimmermann, U. (2008). Working memory and processing speed as correlates of math skills in adult with learning disabilities (3317770). Retrieved from http://search.proquest.com/docview/304835432?accountid=50773